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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re PATENT APPLICATION OF:

SCHREIBER et al

Group Art Unit: 3726

Appln. No.: 09/731,250

Examiner: Trinh Nguyen

Filed: December 7, 2000

DKT: 2560-0227

Title: Method For The Manufacture Of A Combustion Chamber Of A Gas Turbine Engine

DECLARATION OF KARL SCHREIBER

The undersigned inventor, Karl Schreiber, in support of allowability of claims rejected in the referenced application (See Examiner's Official Action dated July 12, 2006), hereby declares as follows:

1. I have a Diploma of Engineering in Materials Technology from the University of Applied Sciences in Osnabrück, Germany. This would be considered to be a more advanced degree than a Bachelor's degree in Engineering and is an immediate prerequisite for a Doctorate degree in engineering in Germany. I am certified as a European Welding Engineer by the Welding Institute of Munich (Germany). This certification also requires the Diploma of Engineering as a prerequisite prior to beginning coursework. The coursework for this certification takes approximately 800 hours to complete and there is a final examination which must be passed to achieve the certification.
2. I worked for 3 years as an expert in High Temperature Materials and Testing for MAN Technology (a manufacturer of commercial vehicles, diesel engines, compressors and turbines)

in Munich, Germany. My primary responsibilities included low cycle fatigue (LCF) testing and chemical vapor deposition (CVD) surface technology. I then worked for 1 year as a Welding Technologist for Zeuna Strker, in Augsburg, Germany, a manufacturer of automotive exhaust systems. In this position, I reported directly to the company Board of Directors. My responsibilities included all aspects of welding technology for the company. I next worked as a self-employed consulting engineer in Munich, Germany and worked for many companies in Germany and Switzerland. I consulted in the areas of surface preparation of titanium for application in aerospace, hip gears for use in artificial hip replacement in humans, cycleglasses and chemical industries. I also consulted in physical vapor deposition (PVD) technology and did research and development consulting for the materials department of MTU (a manufacturer of turbine engines). I also started and ran a small business that manufactured mountain climbing equipment from titanium alloys.

3. For the last 14 years I have worked for Rolls-Royce Deutschland (and its corporate predecessor BMW Rolls-Royce). Our company is a manufacturer of turbine engines, primarily for aerospace use, and it and its corporate predecessors have been manufacturing aircraft engines since 1908 and aircraft turbine engines since 1959. I have been the Manager of Materials Research & Technology since 2002. My responsibilities have included working in the Mechanical Testing Lab, welding technology and processes for the company, including laser welding processes, manufacturing processes including chip and chipless electrochemical (ECM) machining, materials R&D (as the materials MTO – module technology owner). I was also the coordinator of our UDIMET® 720Li and MMC Fan R&D project. UDIMET® 720 Li is a polycrystalline nickel-base superalloy conceived in the late 1990's and this project

researched and developed its use for application in a metal matrix composites (MMC) fan for our turbine engines.

4. I am a coinventor of the subject application identified above. Counterpart patent applications in Germany and Europe have already granted as patents.

5. I am the sole inventor or a coinventor of the additional following 13 US patents and pending patent applications. Where only my name is listed, I am the sole inventor. Where an "et al" is used, I am a coinventor.

<u>Number</u>	<u>Name</u>	<u>Date</u>	<u>Title</u>
7,076,942	Schreiber	July 18, 2006	Protective Ring For The Fan Protective Casing Of A Gas Turbine Engine
7,033,131	Schreiber	Apr. 25, 2006	Fan Blade For A Gas-Turbine Engine
6,997,995	Janschek et al	Feb. 14, 2006	Method For Producing Components With A High Load Capacity From TiAl Alloys
6,745,931	Karl et al	June 8, 2004	Method For The Production Of A Sealing Element
6,532,658	Schreiber	Mar. 18, 2003	Process For The Manufacture Of A Blade/Vane Of A Turbomachine
6,411,085	Siegel et al	June 25, 2002	Method For Detecting Defects In Work Pieces And Facility And Magnetic Field Measuring Apparatus For Implementing Said Method
6,251,494	Schreiber	June 26, 2001	Honeycomb Structure Seal For A Gas Turbine And Method Of Making Same
20050097891	Schreiber	May 12, 2005	Arrangement For The Cooling Of Thermally Highly Loaded Components
20050084379	Schreiber	Apr. 21, 2005	Compressor Blade Root For Engine Blades Of Aircraft Engines
20050079059	Schreiber	Apr. 14, 2005	Hollow Fan Blade For Aircraft Engines And Method For Its Manufacture
20050016842	Schreiber	Jan. 27, 2005	Fixture For Electro-Chemical Machining

20040184921	Schreiber	Sep. 23, 2004	Compressor Blade For An Aircraft Engine
20040182843	Schreiber et al	Sep. 23, 2004	Method For Joining Components In Titanium Aluminide By Brazing

I am also the inventor or coinventor on corresponding counterpart German and European patents/patent applications for most of the above US patents/applications.

6. I have reviewed the Office Action of July 12, 2006 and the Examiner's comments therein.

It is very desirable with aircraft turbine engines to have combustion chambers of high strength and low weight. In recent years, much effort has been expended toward reducing fuel consumption, increasing power density and reducing emissions of aircraft turbine engines. This effort has resulted in attempts to develop engine components that are capable of higher temperature operation without a reduction in strength, so that less cooling air need be used to cool components and such air can be used for combustion.

The background section of the subject specification states:

Gas-turbine combustion chambers are normally made of forged and/or rolled rings which are subsequently machined and suitably drilled. For increased thermal strength, thermal barrier coatings are partly applied to the rings. The dome of the combustion chamber, which is subject to extremely high thermal stress, is in some designs made as a casting in a highly temperature-resistant nickel-base casting alloy. The rings and the dome of the combustion chamber are usually joined by welding, however, the thermal strength of this weld joint is inferior to that of the casting, this circumstance being due to the limited thermal strength of the weld filler material.

The manufacturing route, i.e. the forging and subsequent machining of the ring and, if applicable, the subsequent welding of the cast dome, incurs an enormous manufacturing effort. Furthermore, the forging materials available are inferior to the precision casting materials available in terms of their thermo-mechanical strength above 1000°C, as a result of which a considerable share of

the air compressed in the compressor of the gas-turbine engine is to be used for the cooling of components and is thus not available for combustion. This impairs the power density, the specific fuel consumption and the pollutant-emission characteristics of the gas-turbine engine.

This background text states that (emphasis added) "the dome of the combustion chamber ... is in some designs made as a casting in a highly temperature resistant nickel-base alloy". However, prior to my invention, I am unaware of any combustion chamber of any size where a cast dome of highly temperature resistant nickel-base alloy was welded to a combustion chamber ring cast of the same alloy. Rather, as discussed, this prior art cast dome of highly temperature resistant nickel-base alloy (having the required thermal strength to about 1150° C) could only be welded to a combustion chamber ring made of a forgeable or formable material having a lower thermal strength (to only about 850° C maximum). This ring was not cast, nor was it made of the same alloy as the dome. Further, the weld joint in such a prior art embodiment had to be made outside of hot spot areas of the combustion chamber because of the limited thermal strength of the weld joint. Such a prior art combustion chamber has a lesser thermal strength than my inventive combustion chamber and, as stated in the specification as noted above, required additional cooling air to cool the combustion chamber, at the expense of power density, fuel consumption and polluting emissions.

Thus, contrary to the Examiner's assertion at paragraph 6 of the Office Action, the AAPA does not teach or suggest "that it is known to make a combustion chamber of a gas turbine by 'casting in a highly temperature resistant nickel-base casting alloy' (see paragraph 2 of page 1 of the specification)." Rather, as discussed above, the specification only teaches that a dome of the combustion chamber could be cast of the highly temperature resistant nickel-base casting alloy. The ring of the combustion chamber was not cast from the same alloy as the

dome, but was forged from a different formable alloy of inferior thermal strength. Thus, even though such a dome and such a ring were known to be welded, they were of different alloys and only the dome was cast. Further, because the dome and the ring were of different alloys, a filler material was required for such welding, which further degraded the strength of the weld joint. I believe that it was unknown prior to my invention to make a combustion chamber for a gas turbine engine where at least two components of the combustion chamber were both cast from the same highly temperature resistant nickel-based casting alloy and then welded together such that the welded joints have a thermo-mechanical strength substantially the same as the individual components, i.e., the welded joints do not have an inferior thermo-mechanical strength as compared to the welded components.

7. The Examiner states that the requirement in claim 1 that "the welded joints have a thermo-mechanical strength substantially the same as the individual wall sections" is not supported in the specification. I believe this to be incorrect. The first page of the specification specifically discusses the inferior thermal strength of a previously known welded combustion chamber (emphasis added): "The rings and dome of the combustion chamber are usually joined by welding, however, the thermal strength of the weld joint is inferior to that of the casting, this circumstance being due to the limited thermal strength of the weld filler material." The specification goes on to state that (emphasis added) "the present invention provides a method enabling larger combustion chambers of gas-turbine engines to be completely manufactured of a casting material, i.e., from wall sections made by a casting process. It is a particular object of the present invention to provide remedy to the above problematics by providing wall sections which are joined together by laser welding to make up the combustion chamber." (p. 2).

The specification goes on (emphasis added) "According to the present invention, the individual cast wall sections of a gas-turbine combustion chamber are to be joined by laser welding. In particular if the casting element is a highly temperature resistant nickel-base casting alloy, the low energy input of the laser welding process will enable a crack-free joint to be made between the wall sections in the nickel-base casting materials. (p. 3) "The method produced by the Specification provides for reduced manufacturing costs and increased thermo-mechanical strength of the combustion chamber". (p. 3)

Thus, since it is specifically stated that "The rings and dome of the combustion chamber are usually joined by welding, however, the thermal strength of the weld joint is inferior to that of the casting, this circumstance being due to the limited thermal strength of the weld filler material" and then "It is a particular object of the present invention to provide remedy to the above problematics", the specification clearly sets forth that the invention provides a weld joint with a thermal strength that is not inferior to that of the casting, or, in other words, "the welded joints have a thermo-mechanical strength substantially the same as the individual wall sections"

The strength of a combustion chamber is only as great as the strength of its weakest part and a weakness of a combustion chamber weld joint because of inferior thermal strength at the weld joint severely threatens the viability of the entire combustion chamber. Therefore, I believe my specification makes clear that my invention creates an improved combustion chamber by, inter alia, eliminating weld joints of inferior strength, which compromise the entire strength of the combustion chamber, and replacing them with welds that do not have inferior strength, but have substantially the same strength as the individual wall sections. While the exact text added to claim 1 is not explicitly stated in the specification, I believe the substance of the text is fully supported by the specification.

8. I have reviewed Johnson, US Patent 5,430,346. Johnson is directed to the laser welding of spark plugs. While such spark plugs are exposed to high temperatures, they do not endure the high mechanical stress that a gas turbine combustion chamber does. Significantly, these spark plugs are relatively small in size and the welded components of the spark plugs are even smaller. These small components do not encounter the residual stresses that occur in welding large components such as the combustion chamber components of the claimed invention. The bigger the components welded, the greater the residual stresses that occur under conventional welding. The residual stresses that occur under conventional welding of large components, such as the combustion chamber components of the present invention, weaken the welded assembly and can result in catastrophic failure of the combustion chamber.

The claimed method provides a welding method whereby such large cast components can be welded together without creating the residual stresses found in a conventionally welded combustion chamber, and this results in a stronger, more reliable combustion chamber having a significantly less chance of failure. Therefore, the welding of the small components of a spark plug is simply incomparable to the welding of the large parts of a gas-turbine engine combustion chamber and the mechanical failure of such a spark plug, while undesirable, is substantially less significant than the mechanical failure of a combustion chamber of a gas turbine typically used in an aircraft. Therefore, it is my belief that a person of ordinary skill in the field of gas turbine combustion chamber design/manufacturing would not look to the disclosure of Johnson, relating to manufacturing spark plugs, to solve a problem in manufacturing combustion chambers for gas turbine engines.



Further, nowhere does Johnson teach or discuss laser welding together a plurality of cast individual sections, all of a highly-temperature resistant nickel-based casting alloy. Johnson only teaches the laser welding of a precious metal alloy insert (of platinum, platinum and iridium alloy or other alloy of platinum, or palladium, iridium or an alloy thereof) to a ground electrode 12B or a center electrode 18B of a nickel alloy. See Johnson, col. 5, line 51 through col. 6, line 14. Johnson also teaches the welding of the ground electrode of a nickel alloy to the spark plug skirt 26 of metal shell 20 of conventional structure. See Johnson, col. 5, lines 41-45, col.3, line 66 through col. 4, line 2 and col. 4, lines 42-50. Johnson only teaches laser welding of one component of nickel alloy to another component of another, non-nickel alloy. Such welding would require a filler material because of the different alloys being welded. Nowhere does Johnson teach or suggest that one component of highly-temperature resistant nickel-based casting alloy be laser welded to another component of highly-temperature resistant nickel-based casting alloy.

Furthermore, as discussed above, neither the precious metal inserts welded to the ground electrode 12B or the center electrode 18B, nor the ground electrode 12B welded to the metal shell 20, encounter the extreme mechanical stresses that are encountered by the combustion chamber wall sections and the joints therebetween of the invention of claim 1.

Finally, nowhere does Johnson disclose or suggest a component formed from a plurality of laser welded wall sections of a highly-temperature resistant nickel-based casting alloy where the welded joints have a thermo-mechanical strength substantially the same as the individual wall sections. Johnson never even addresses the strength of the welded joint, whether laser welded or not. This is not surprising to me because of the less critical nature of the strength of the weld joint in Johnson's spark plug, as compared to the combustion chamber of the claimed

invention.

I do not see any disclosure or suggestion in the cited prior art of manufacturing a combustion chamber formed from a plurality of laser welded wall sections of a highly-temperature resistant nickel-based casting alloy where the welded joints have a thermo-mechanical strength substantially the same as the individual wall sections. The prior art method discussed in my specification teaches away from such a method and Johnson, even if applicable and combinable with such prior art, which I believe it is not, as discussed above, is simply silent on the subject.

9. With respect to the Gasse reference, the Examiner states at paragraph 12 that she is merely using Gasse "to show the teaching that the concept of joining technique by laser welding using with or without filler metal/material is an old and well known concept used throughout the art of welding." Gasse discloses this in his background section and the rest of Gasse is completely irrelevant as he teaches an invention for brazing ceramic components. Gasse does not teach or suggest anything about the welding of components of a highly-temperature resistant nickel-based casting alloy. I believe that a person of ordinary skill in the art fully aware of the problems of joining components of a highly-temperature resistant nickel-based casting alloy would not look to Gasse to solve such problems because Gasse has nothing whatsoever to do or say about joining such nickel-based casting alloys either in discussing the prior art or teaching his invention. A statement that welding without filler is known is not a teaching that such an approach can be used in any type of welding process of any type of metal alloy.

While welding without a filler is known, I can find no teaching or suggestion in Gasse or the other cited art that would lead a person of ordinary skill in the art to combine Gasse as the Examiner has done to suggest laser welding without a filler of a plurality of wall sections cast of the same highly-temperature resistant nickel-based casting alloy where the welded joints have a thermo-mechanical strength substantially the same as the individual wall sections. I do not believe a person of ordinary skill in the art would look to Gasse to solve the deficiencies of the AAPA and Johnson with respect to claims 5, 10 and 16.

Even though Gasse discloses or suggests nothing about joining highly-temperature resistant nickel-based casting alloys, welding the individual wall sections without filler material is an important aspect of the claimed invention. By laser welding the individual wall sections without filler material, an inferior thermal strength of the filler material cannot jeopardize the strength of the weld. This results in a stronger weld and a stronger combustion chamber. Since Gasse has nothing to say about joining highly-temperature resistant nickel-based casting alloys, Gasse fails to even recognize the problems that are incurred in welding such highly temperature resistant alloys. For this further reason, I do not believe a person of ordinary skill in the art would look to Gasse to solve the deficiencies of the AAPA and Johnson with respect to claims 5, 10 and 16.

10. None of the AAPA, Johnson or Gasse teach or suggest welding together a plurality of cast components of the same highly-temperature resistant nickel-based casting alloy nor do they teach or suggest that the welded joints of such a welded assembly have a thermo-mechanical strength substantially the same as the individual components themselves.

11. Based on my experience, qualifications, and the prior art of record and for reasons stated herein, it is my opinion that my inventive method would not have been obviousness to a person having ordinary skill in the art at the time the referenced application was filed, based on the cited references of record. It is also my firm belief that the method claimed in the subject application, at the time of filing thereof, was not known, or even attempted or reduced to practice by persons of ordinary skill in the art and thus would not have been obvious.

All statements made herein on the basis of my own knowledge are true and correct, and all statements made on information and/or belief are believed to be true and correct. I understand that willful false statements are punishable by fine or imprisonment, or both, under 18 U.S.C. §1001 and may jeopardize the validity of the referenced application or any patent issuing thereon.

Jan. 11<sup>th</sup>. 2007  
Date

Karl Schreiber  
Karl Schreiber